Fraunhofer IIS

Fraunhofer-Institut für Integrierte Schaltungen IIS

Quo Vadis Mobilfunk – Erfolgsfaktoren für professionelle Anwendungen und Industrie 5.0

Prof. Dr. Albert Heuberger

The Future of Industrial Communication

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The Purpose of 6G

Technologies for the future – The future of technology

Connect people

6G should bring together even more users.

CO_2-Footprint

Green 6G for a green world.

Enabling the Future

6G for an intelligent future.

Industry 5.0

Human Centric, Intelligent, Resilient, Sustainable

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- Low Footprint
- Circular Economy
- Zero Energy

Sustainable

Human-Centric

- True Collaboration
- Up/Re-Skilling
- Enhanced Safety

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Industry 5.0

Resilient

Intelligent

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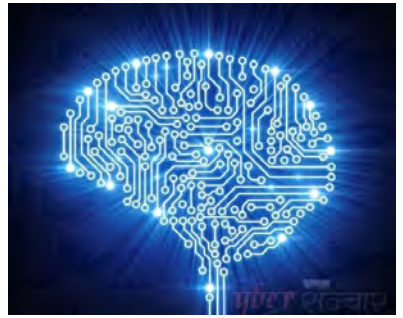
- Flexible Production
- Adaptive Production
- Wireless Production

- Aware Production
- Sensing and Communication
- Continuous Learning



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The Reality of Industrial Communication

5G for Industrial Communication
Current challenges and hurdles

Ongoing Release Pipeline
New features and technologies appear
Availability in the standard vs product availability

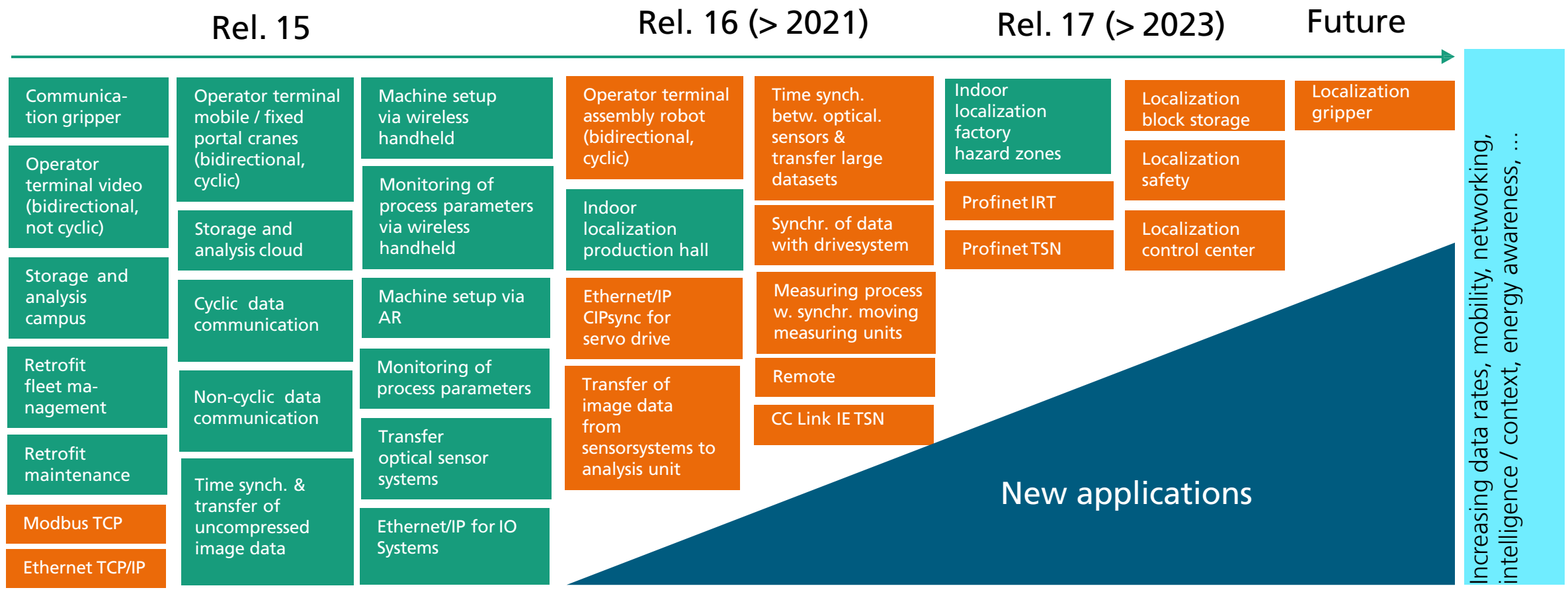
Difference between theory and practice
Is a Use case really working?
Is interoperability given?
How do I connect my existing (old) machines?

Do I need 5G?
Is 5G the solution I need?
What else could solve my problem?
What alternatives is the market offering?

5G networks offer high potential for companies but **validation upfront** – technical and from a business perspective - difficult

Market is changing
New players arise
Requirements of customers and regulators are changing
New ecosystems are developing.

Selected Examples of Industrial 5G Applications
and their support by 5G releases



Requirements are met under certain conditions or for certain applications

Requirements are fully met

* Use Cases from the VDMA-Guideline „5G im Maschinen- und Anlagenbau“, year corresponds to the expected commercial availability of 5G release, not all parts of the standards will be available on all HW/SW platforms; **https://ea.vdma.org/leitfaden5G**

Our Mission

Closing the gap between standardization and deployment

Testbeds »Industry 4.0« und »Automotive«

Testcenter at Fraunhofer IIS in Erlangen

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Hands-On 5G Experience

Fraunhofer IIS activities to support the adoption of 5G

Industrial Projects

Projects on the potential of 5G new radio positioning, 5G NTN or Use Case validation

Testbeds

Test Center, Testbeds Industry 4.0 and Automotive, Mobile Campus Network

Research Projects

Several - e.g. 5G Opera – Building an European Open based private network ecosystem

Studies and Consulting

Studies for MNOs, Technology roadmaps for companies

5G and Beyond

Prototyping, Open Air Interface, Open RAN, AI, 6G

Hands-On 5G Experience

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Open RAN Testbed Industry 4.0 in Nürnberg

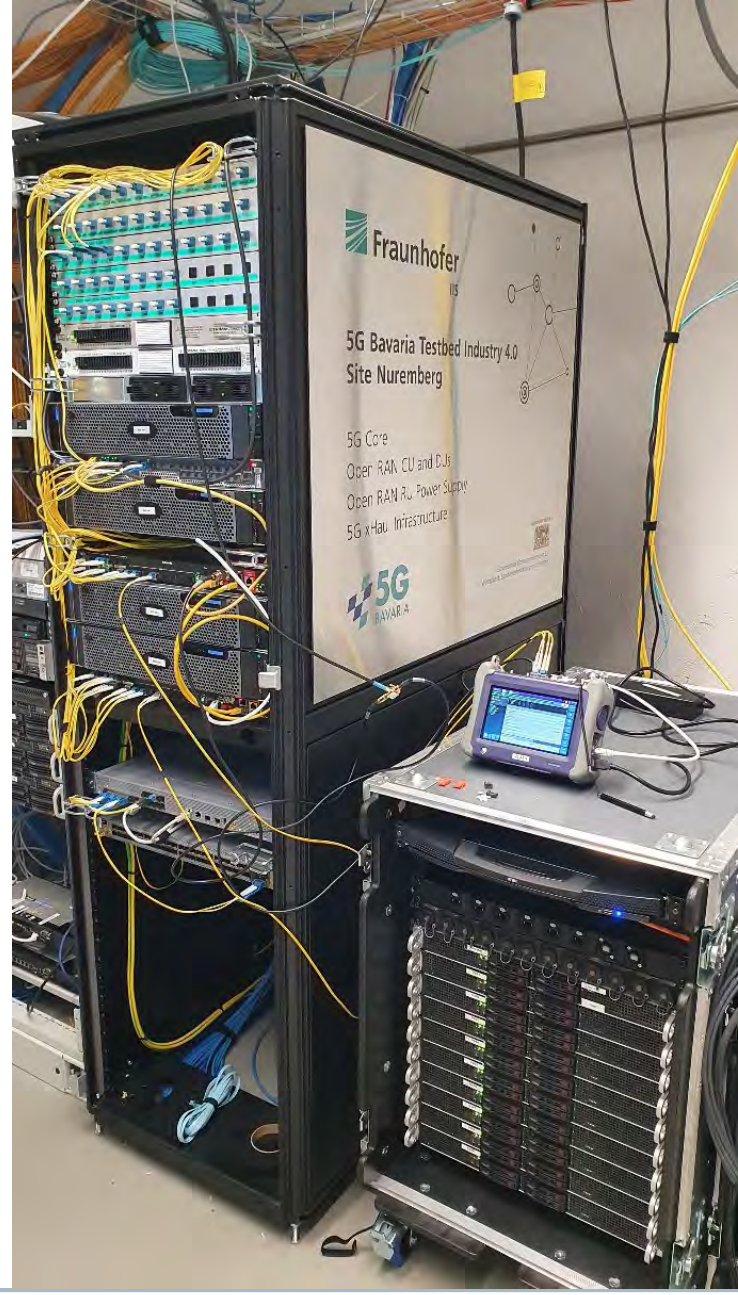
Communication, Localization, Edge Computing

Challenges

- Provide 5G testbed to Industry and smaller companies to enable access to this new technology and support in development but also decision making in aspects of Communication and Positioning

Our solution

- OpenRAN based 5G Campus network operating at full 100MHz 3,7GHz to 3,8GHz
- Multi Vendor environment with „all on premise“ technology
- Fully virtualized system running on commercial Hardware and enabling high end MEC
- Prepared for enhancements mmWave and massiveMIMO
- Combines industrial communication and positioning



5G C-V2X Testbed in Rosenheim

Three sites, fully controlable, handover, roaming

Challenges

- Development of applications for connected cars (using new generations of mobile communications) and validation for vehicle series production

Our solution

- Controlled 5G test environment for repeatable evaluations along routes within and around the city of Rosenheim
  - Freeway / motorway A8
  - Federal route B15
  - Rural and urban roads
  - Railroad segment
- Self-contained mobile network: 3 antenna sites with up to 3 cells per site
- Cell hand-over and network roaming scenarios
- Operational since May 2022

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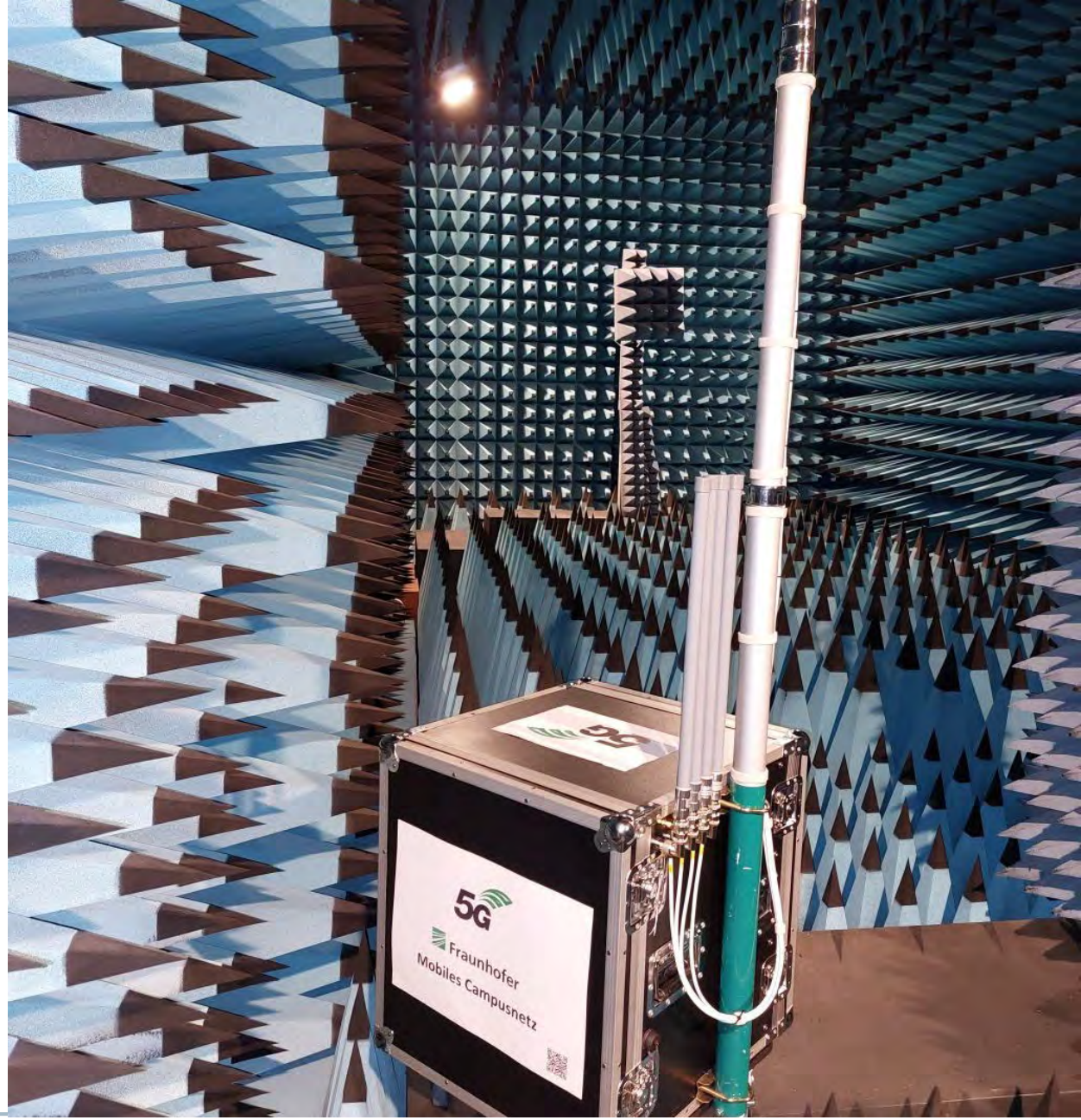
Mobile Campus Network
On-Site 5G experience

Challenges for professional 5G users

- campus networks are a substantial long term investment (small campus network starting from 200 k€ invest + opex…)
- companies lack hands-on experience in understanding what they really need and how benefits of 5G could look like (especially in terms of Business Cases…)

Our solution

- mobile campus network as low-entry offering, where companies can get experience with 5G, test in their own facilities and understand how a solution could look like



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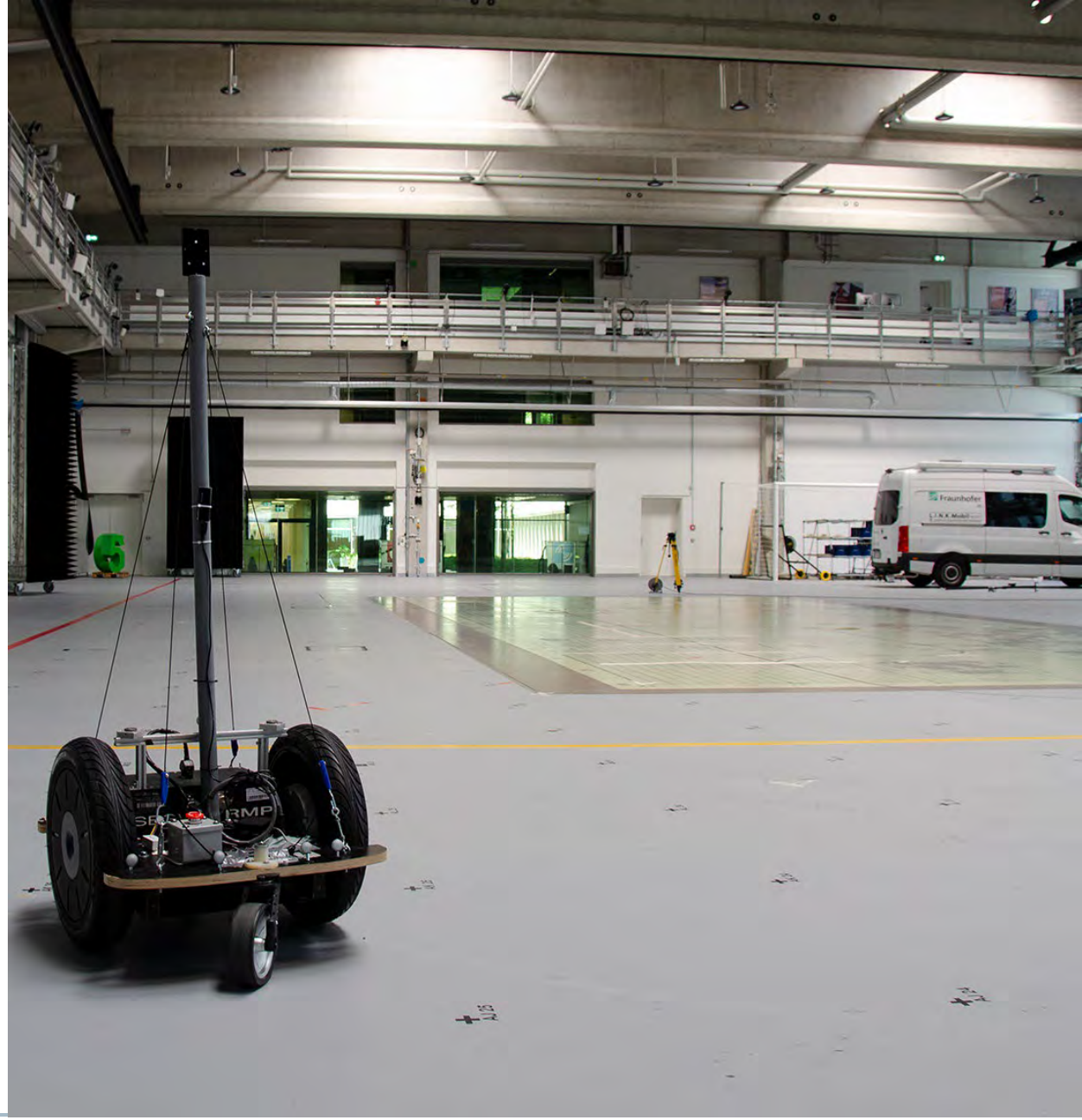
Mobile Positioning Network
Evaluating 5G positioning performance

Challenges for companies:

- 5G localization is standardized, but what is the achievable accuracy and speed?
- 5G defines 7 positioning service levels, but how can I ensure that it is applicable for my use cases?

Our Solution

- 5G positioning as an add-on for existing campus networks
- Nomadic approach to open up new areas of application
- Use-case evaluation in real scenarios with reduced effort



Wireless Network Analysis

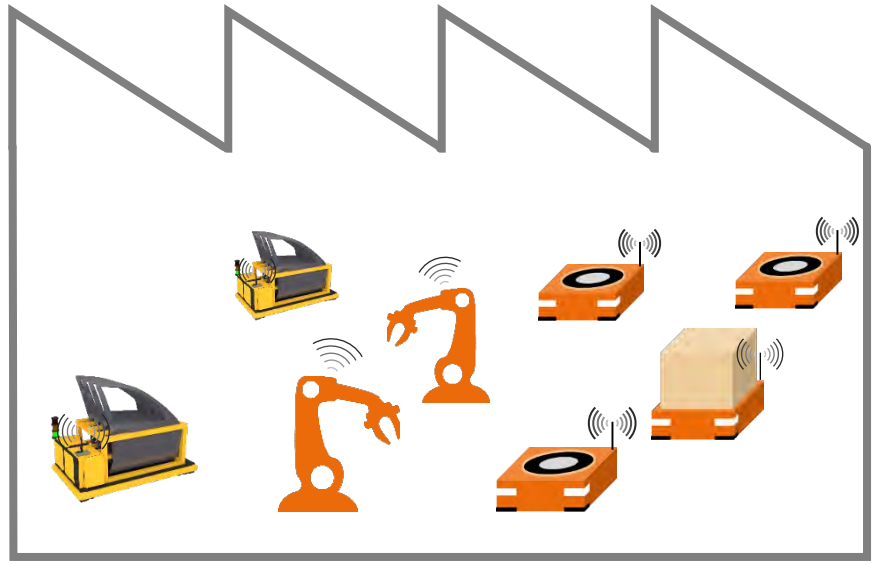
Real-time wireless traffic monitoring

Challenges

- Wireless spectrum highly crowed in production shop floors
- Wireless connectivity disturbances can impact easily production processes causing financial losses
- Autonomous network monitoring and healing required for URLLC scenarios

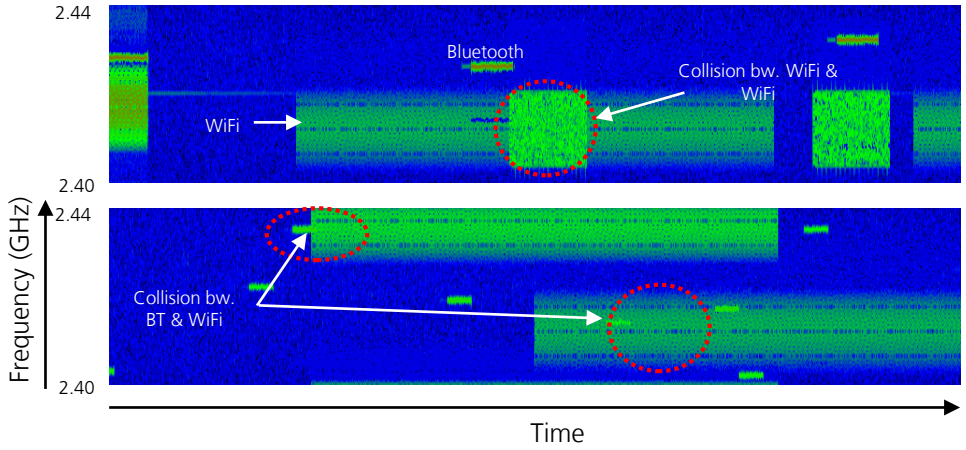
Our Solution

- 24/7 realtime surveillance of RF bands of interest
- Gapless surveillance of spectrum occupancy, automatic detection of wireless technologies and mutual interference
- Suitable as passive monitoring node or integration in O-RAN DUs



Why is my application not working?

Operators & workers



*Example captured in ISM band

5G Technology Development

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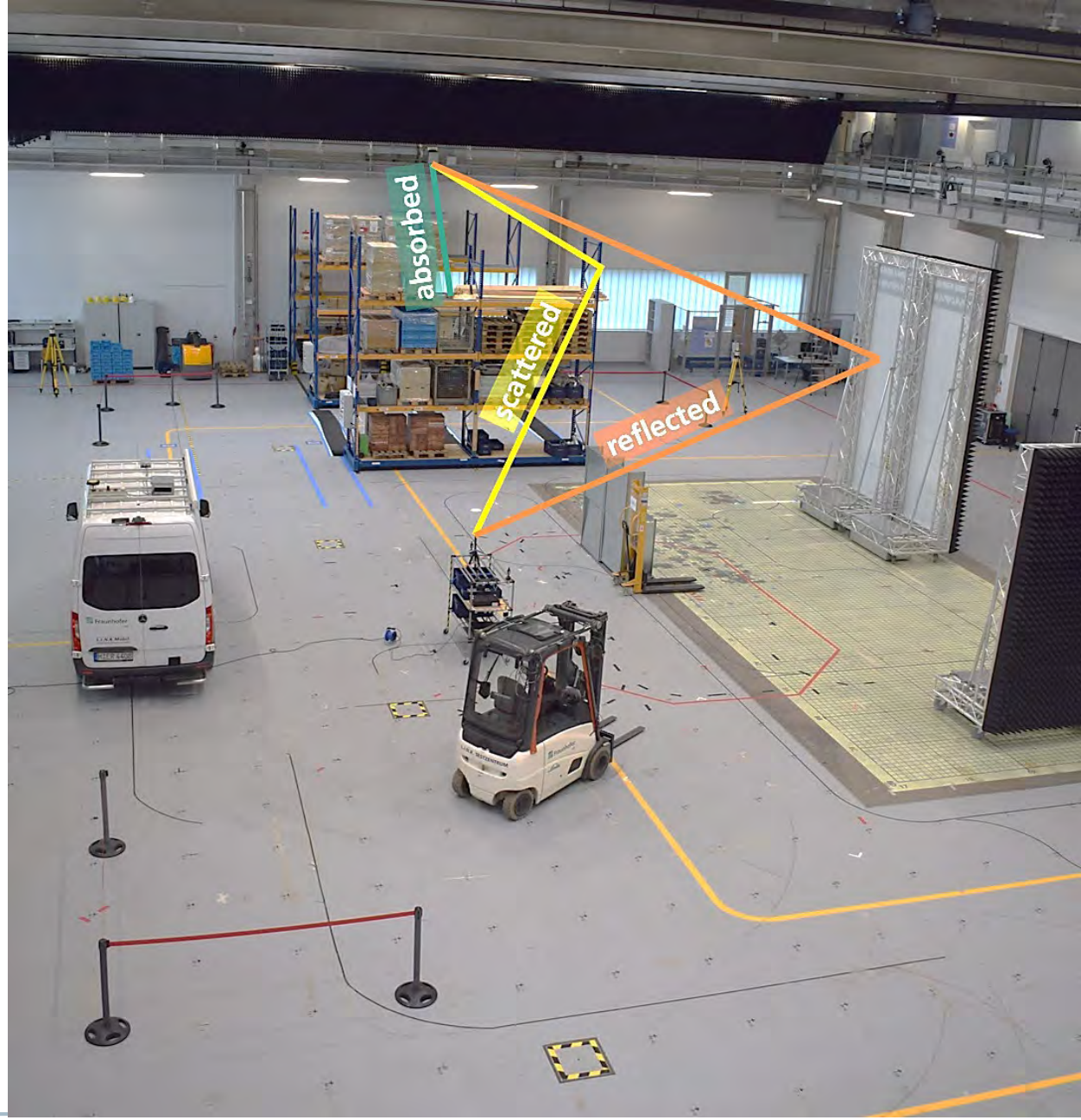
5G Positioning
Technology development at Fraunhofer IIS

Challenges

- Positioning for industrial use cases is a new topic for mobile radio
- Commercial solutions for private, industrial networks are not available, yet
- Multipath propagation in industrial environments causes time measurement errors

Our Solution

- Focus on relevant aspects: 5G spectrum, signals, deployment
- Use of AI to ensure high accuracy and robustness



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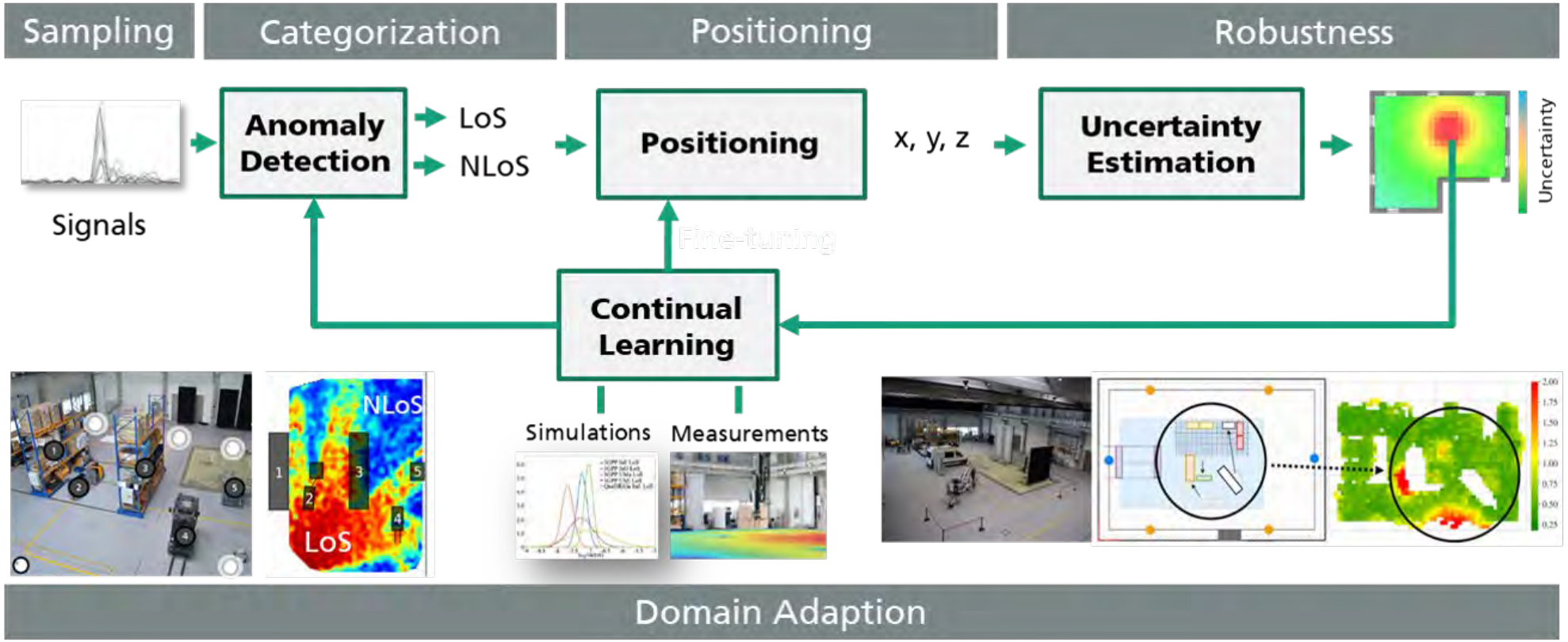
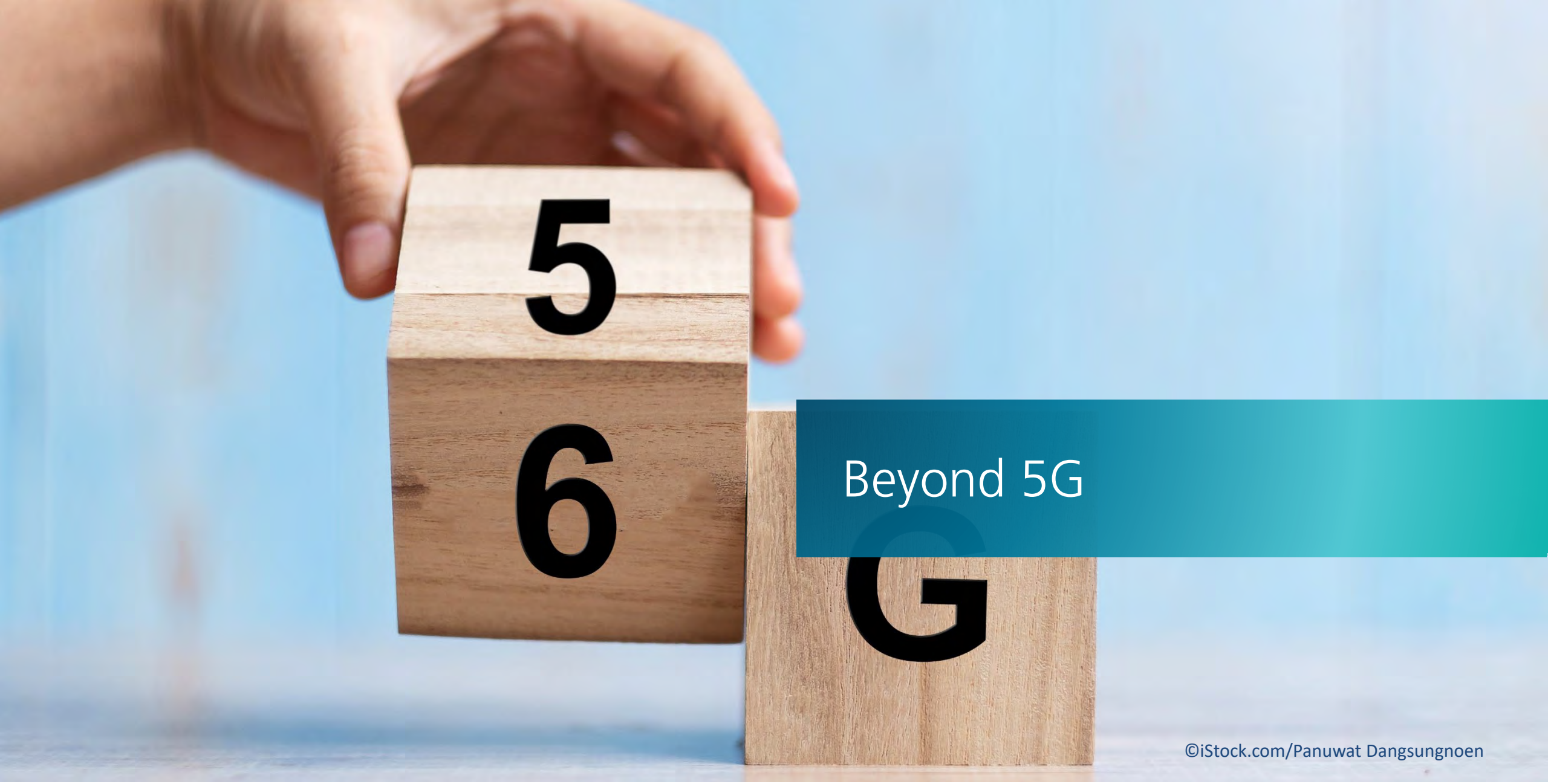
5G Positioning

Comprehensive AI-enabled SDK tool-box

Our AI research to enable precise 5G positioning with high reliability for industrial use cases:





Beyond 5G

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UWIN
Optimized for critical IoT applications

Challenges:

- 5G announced 1 ms delay, but reality shows:
- QoS classes defined in 3GPP not sufficient for all I4.0 and I5.0 applications (e.g. motion control, robotics etc.)
- QoS cannot be achieved in all public networks

Our solution:

- UWIN is a sub 100µs latency and high reliably radio interface, which can be integrated in a 5G network (e.g. via standardized N3IWF interface)

UWIN evaluation kit

MIOTY

A New Class of Low Power Wide Area Networks

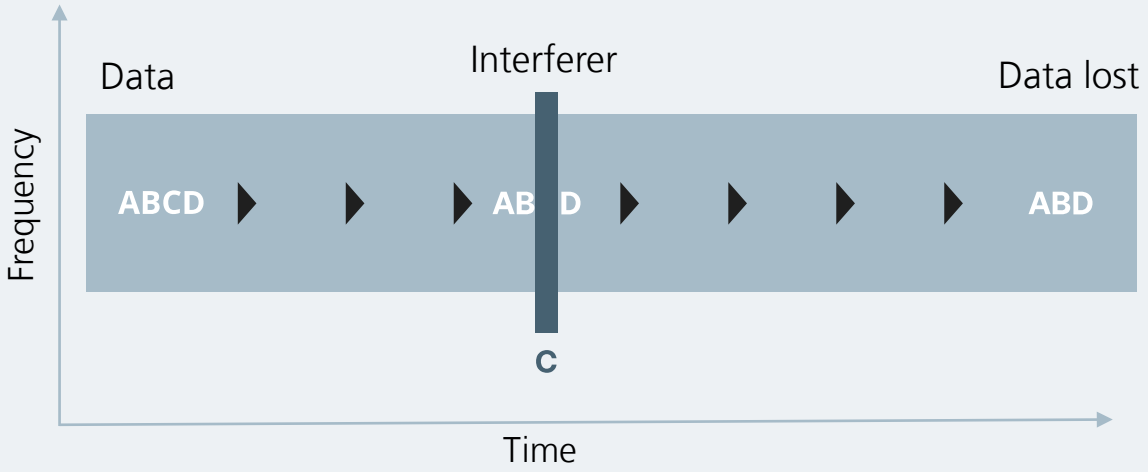
Challenges

- 5G offers mMTC via NB-IoT technology, down to a data rate of ~30 kbps in 180 kHz, but for LPWA applications, the power consumption is still too high and the coverage limited
- Classical LPWAN technologies suffer from low resistance against interference, high packet error rates (PER) and limited scalability

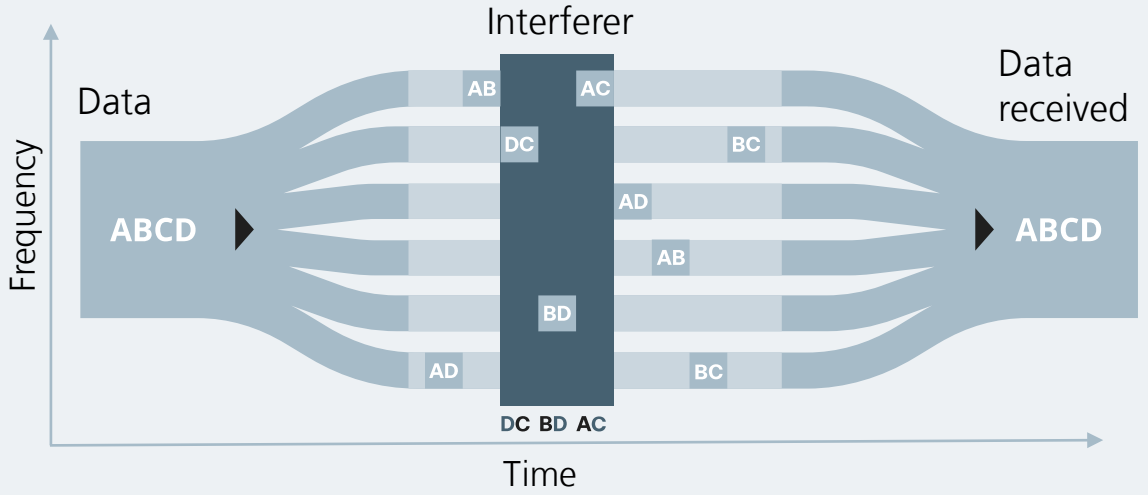
Our solution

- MIOTY combines advantages of LPWAN's (low power, long range) with those of cellular technologies (high reliability & scalability)
- First roll-outs in smart metering (Pirna, Erfurt) and building management (QuadReal), projects in industrial applications (BMW)
- World wide industry alliance with more than 35 members: www.mioty-alliance.com

Existing LPWAN Systems



Telegram Splitting (mioty)



Back to the Future: 6G Research

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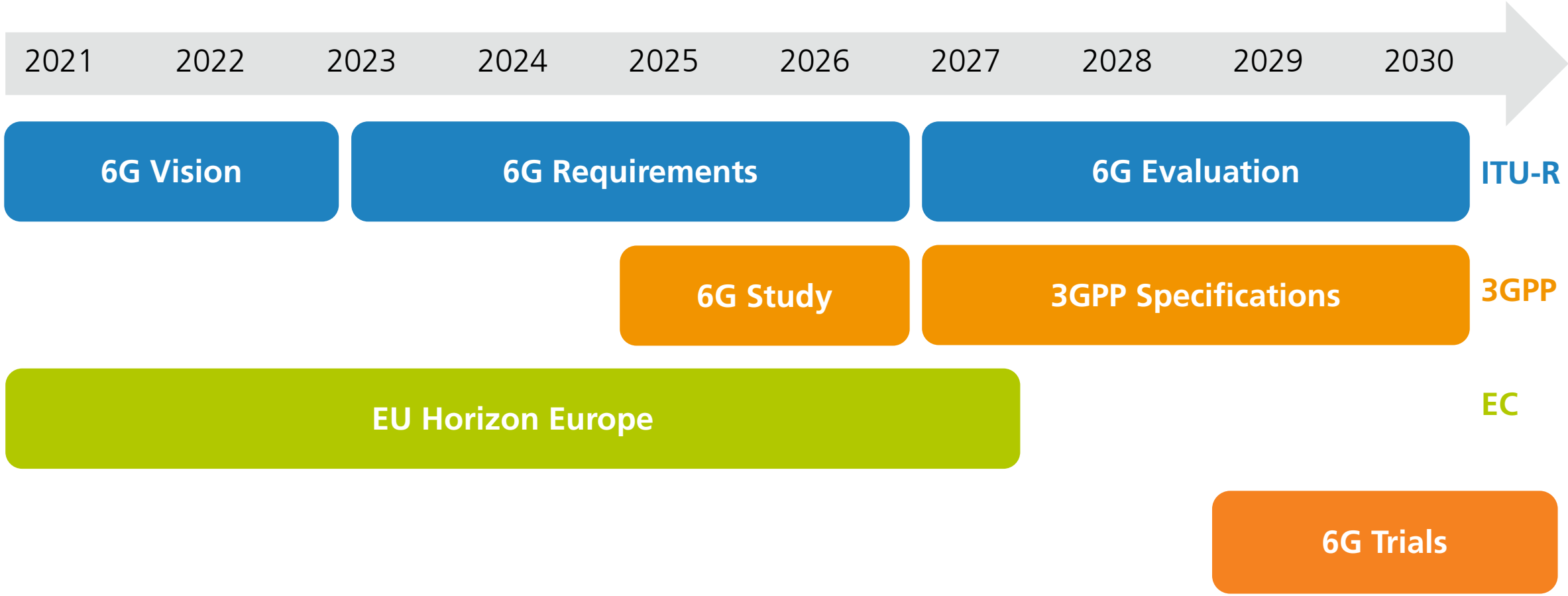
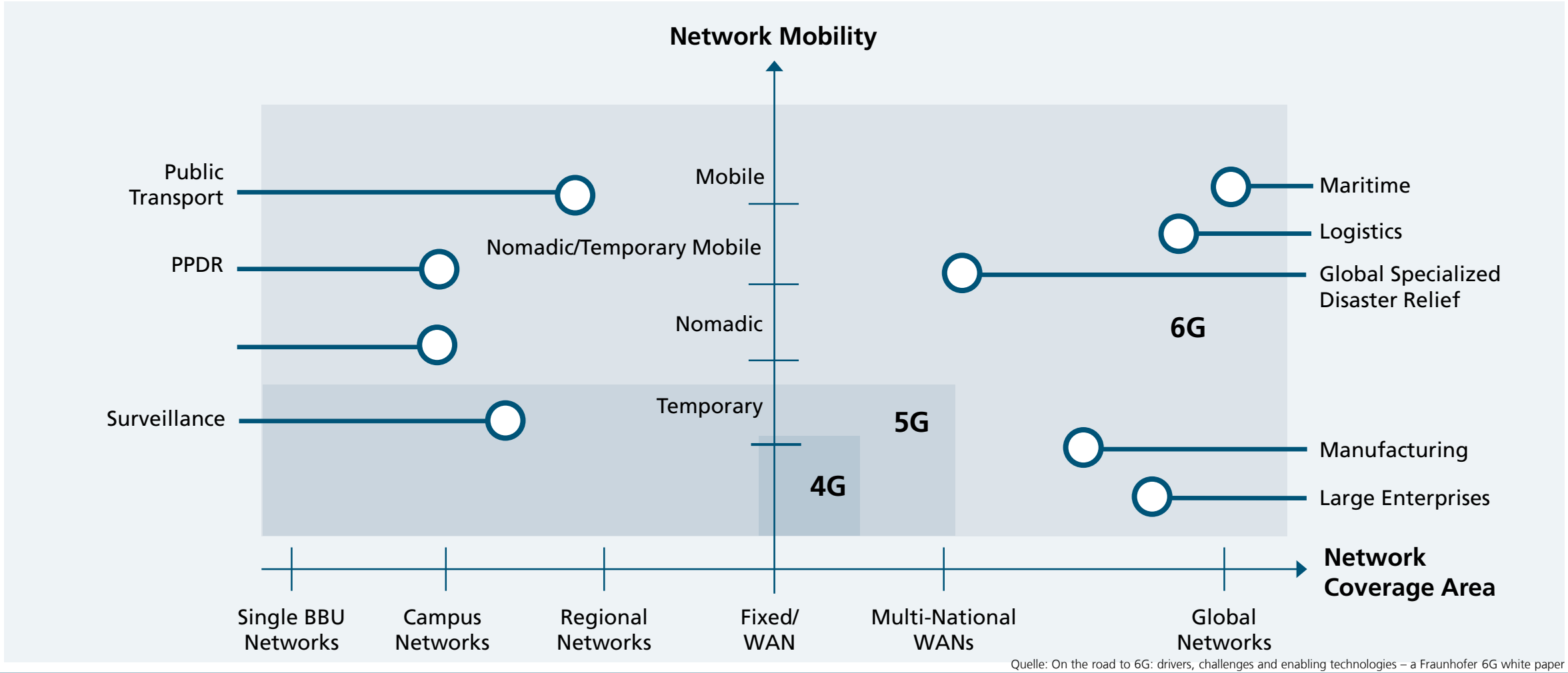
6G Time Line

Research, Standardization, Deployment



6G Connectivity

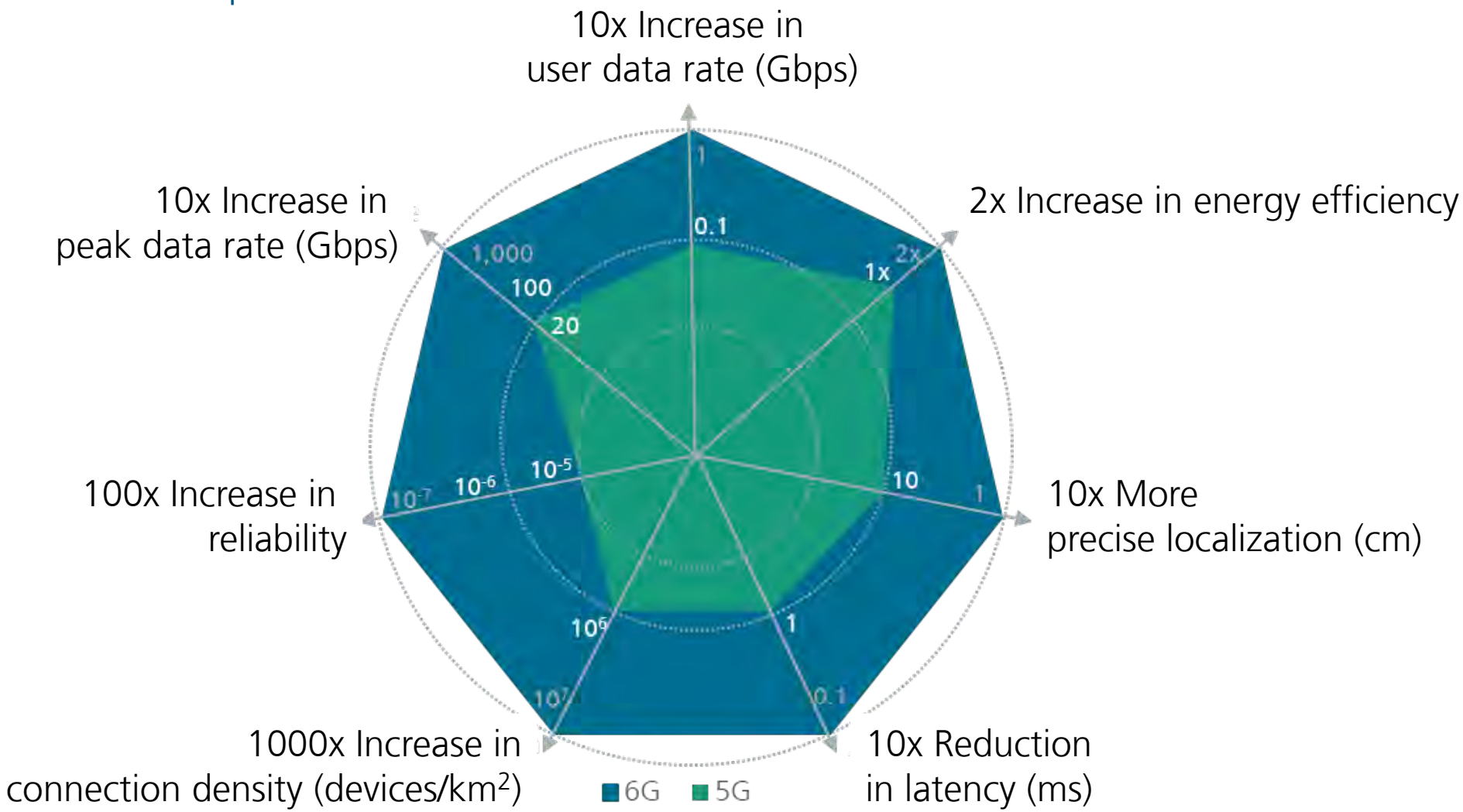
Multitude of mobility and coverage scenarios



Quelle: On the road to 6G: drivers, challenges and enabling technologies – a Fraunhofer 6G white paper

6G Connectivity

Expected performance improvements



Sustainability

Sustainability is a **key driver** for innovation

TECHNOLOGY

- Green Architecture
- Green ICT
- Power Saving Techniques
- Edge Intelligence
- Virtualization of the Network
- AI/ML for Orchestration
- Green Massive MIMO
- Energy Efficient Signal Waveform

EVALUATION

- KPIs
- Carbon Footprint
- Energy Models
- Validation and Testbeds
- Standardization
- Decarbonization Options
- Component Lifetime

Sustainability

Our current **Research Activities** related to **sustainability**

6G Platform Germany
→ Lead of Group »Sustainability«

Edge Limit
→ Limit consideration of power electronics

Green ICT – Sensor Edge Cloud Hub
→ Reference platform for environmental accounting of ICT systems and components

3GPP - 5G Standardization
→ Activities in Release 16/17 and 18
→ Network Energy Savings

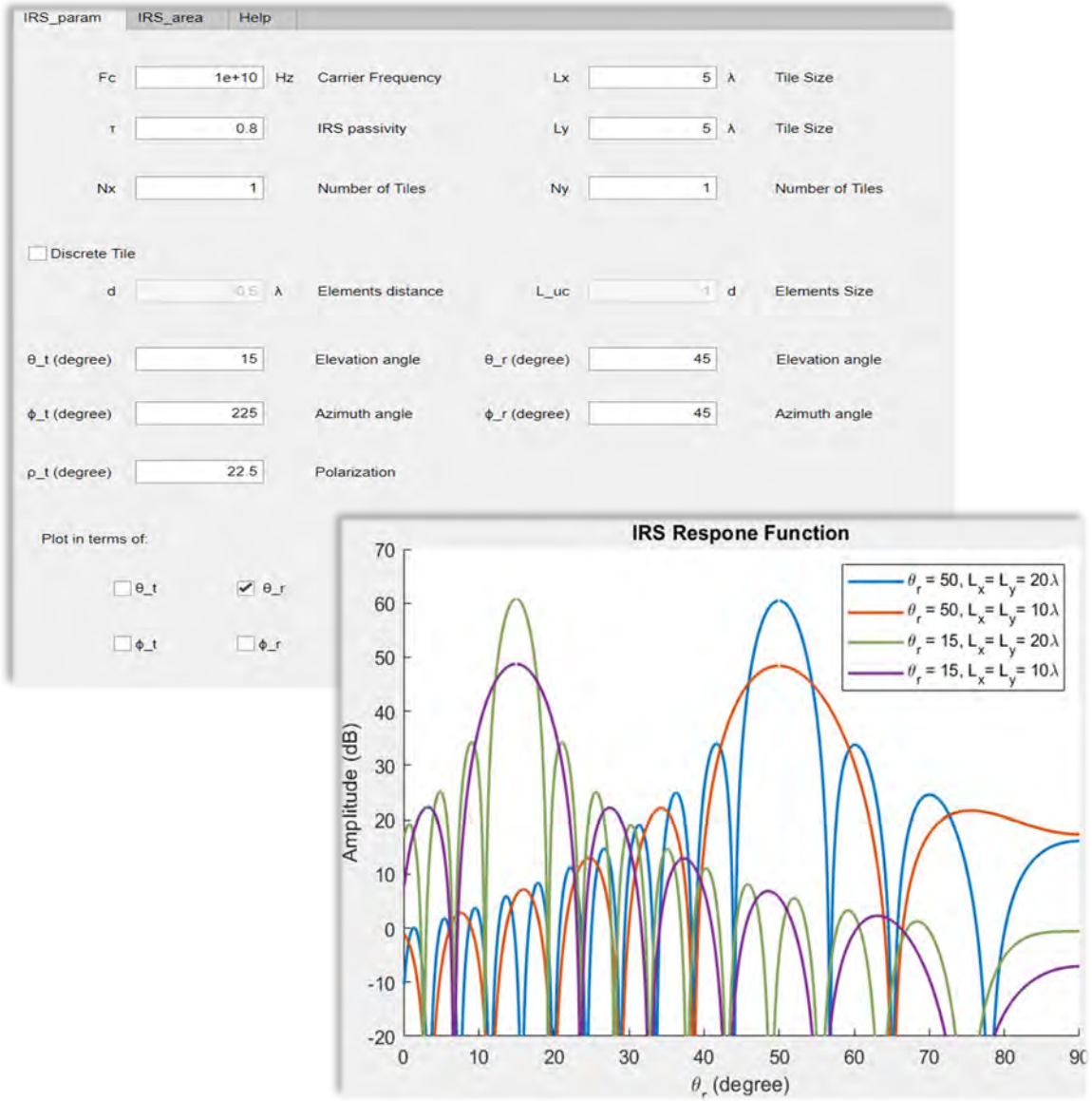
Member and contributions
→ NGMN – GFN
→ AIOTI – Digital for Green / Standardization

Applied Research on IRS
IRS (Intelligent Reflecting Surface)

Interacting with the basic research community towards **IRS application**

IRS Simulations and Setups for Real-World-Trials

- **IRS simulation model** of controllable arrays of reflectors
- IRS incorporation in 3GPP channel models and simulation **scenarios**
- Control **algorithms** for IRS
- **SDR-Setups**, e.g. our FR2-Platform, to be equipped with IRS-prototypes and tested in relevant radio environments



Our Research Targets

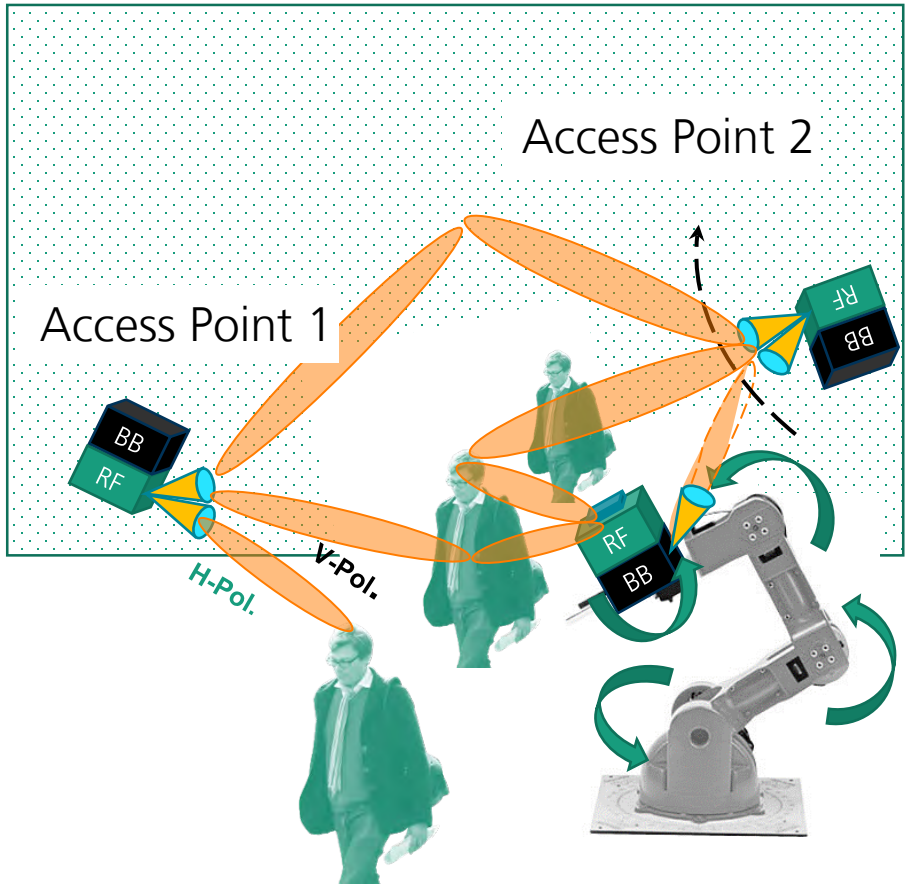
- IRS for **positioning**: virtual anchors, illumination of blocked areas
- IRS for **resilient and secure networks**
- Potential for IRS to reduce **network energy consumption**

THz

Road towards ultra-broadband THz-links in ICAS systems

Challenges

- System design for ICAS-applications (integrated communication and sensing) that benefit from channels with larger bandwidths (>5 GHz)
- Both for communication as for sensing the higher path loss and strongly varying propagation conditions are challenging at sub-THz, consequently a fundamental knowledge of these conditions are a must for system design
- No precise propagation models available for communication and sensing purposes at THz- and sub-THz-range for the targeted applications so far



Our solution

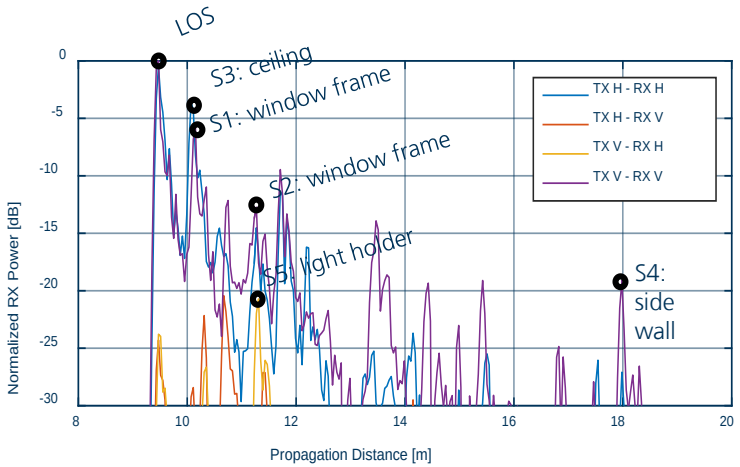
- Development of measurement hardware for channel-sounding and -modelling at sub-THz frequencies
- Full polarimetric 3D Wideband measurement campaigns for various applications
- Channelmodelling and sub-THz ICAS PHY design

THz

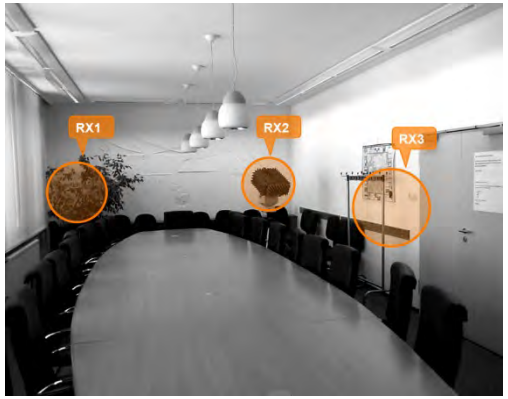
THz-Measurements for future mobile ICAS systems

Channel Measurements and system development

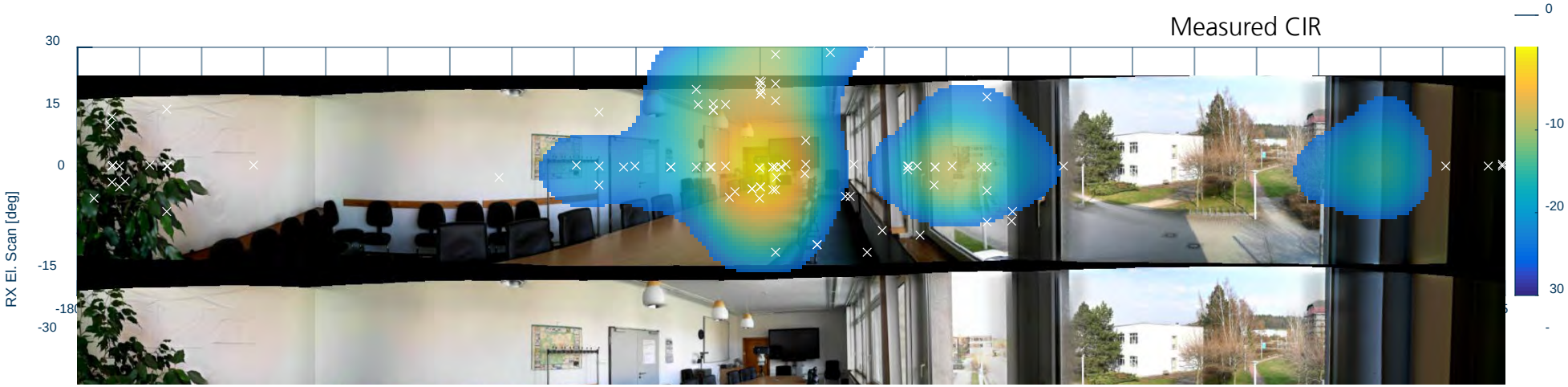
- Full polarimetric double directional 3D-measurements in different scenarios (office, industrial, vehicular, in machine) with high dynamic range in D-/G-/J-Band (100-300 GHz)
- Triple band (sub 6GHz, mmWave, subTHz) for multiband system design
- Channel modelling and statistics for the development of future mobile ICAS systems



Measured CIR



Measurement equipment in conference room



3D-identification of scatterers in a conference room

Summary

- Beyond 5G technologies are expected to provide solutions for Industry 5.0 challenges
- Adoption of 5G technology for Industry 4.0 is gaining momentum
- Environments for tests and verification are essential to bridge the time gap between standardization and product availability
- Scalability, reliability and energy-efficiency are essential
- In 6G, new features such as 3D networks, joint communication and sensing, highly precise positioning and tight integration of AI will open new applications and research fields

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Vielen Dank für Ihre Aufmerksamkeit

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